Philip Chizek, Ph.D.
Marketing Manager
Fuel Cell Vehicle Programs
Sustainable Mobility Technologies

Research & Advanced Engineering

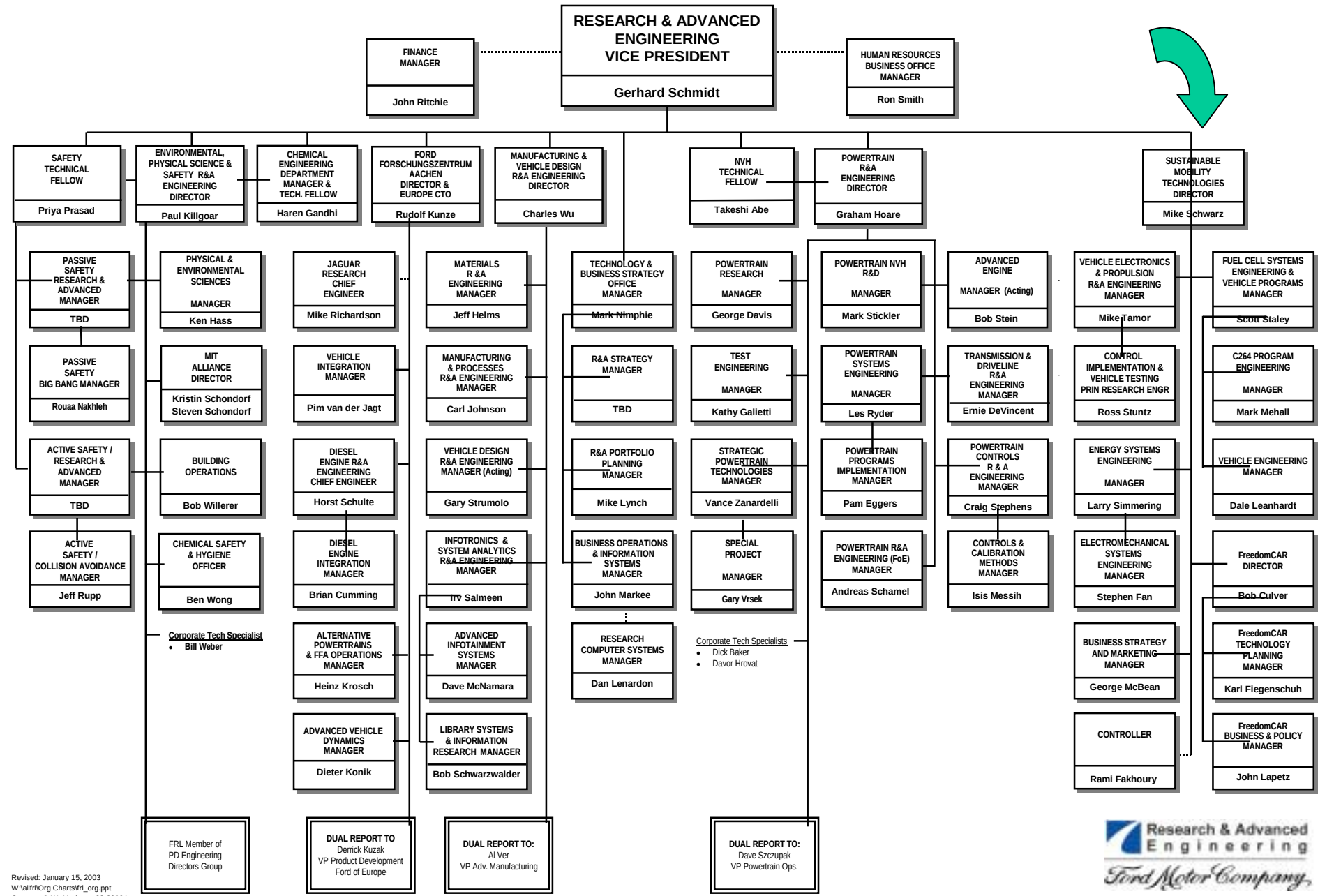
Ford Motor Company

Environmental Vision

“ In today’s world, solving environmental problems is an investment, not an expense.”

William Clay Ford, Jr.
Chairman and CEO,
Ford Motor Company

FORD RESEARCH AND ADVANCED ENGINEERING



Research & Advanced Engineering
Ford Motor Company

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Sustainable Mobility Technologies
Role within Ford's Trustmark

Global Center of Excellence for design & development of electric drive vehicle propulsion technologies:

- Develop Fuel Cell programs for all of FMC brands
- Electric Drive trains for Hybrids and Fuel Cells
- Provide education and awareness about our advanced technologies

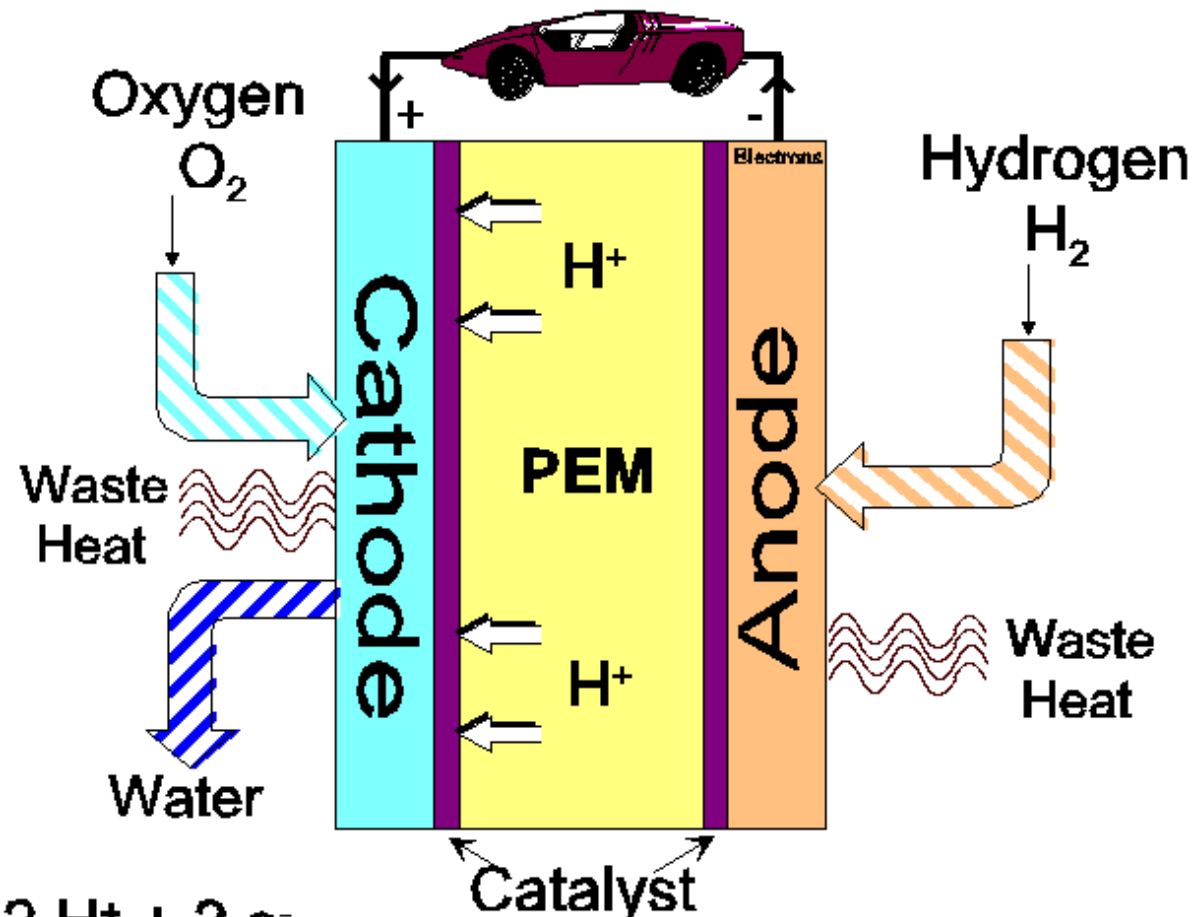
What are we doing at Ford Motor Company?

- **Fuel Cell System Technology Development**
  - **Alliance with DaimlerChrysler and Ballard**
  - **Integration of Core Technologies into Vehicle Programs**
- **Advanced Vehicle Programs**
  - **Fleet Customer Development Program**
  - **Marketing and Demonstrations**
  - **Low Volume Production Programs**
- **Partnerships with Governments & Agencies**
  - **California Fuel Cell Partnership**
  - **FreedomCAR/ FreedomFUEL**
  - **NRCan**
  - **European Consortium**

What is a Fuel Cell?

An energy conversion device that electrochemically converts chemical energy into electrical energy.

Operation of a PEM Fuel Cell

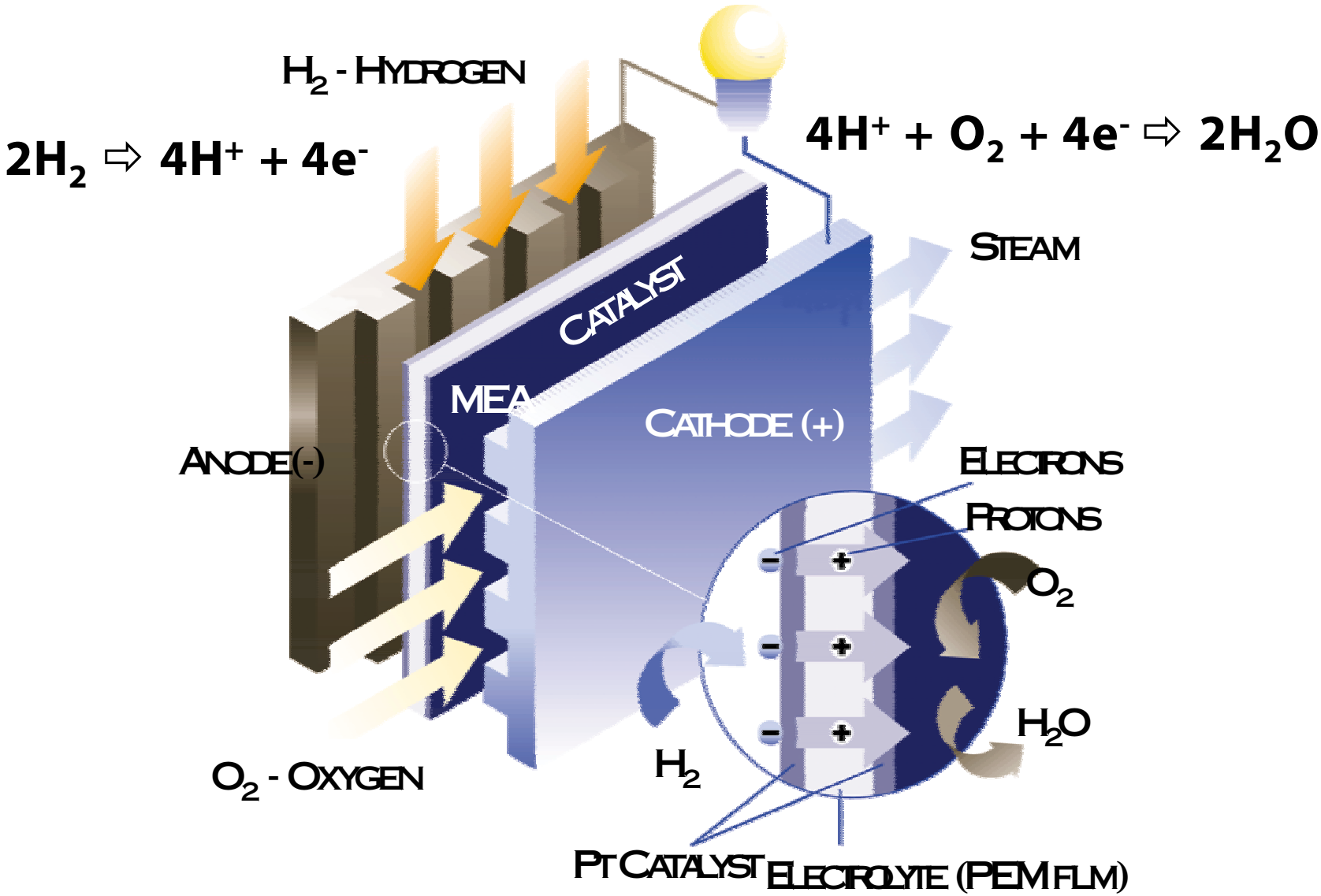


$1/2\ O_2 + 2\ H^+ + 2\ e^- \rightleftharpoons H_2O$

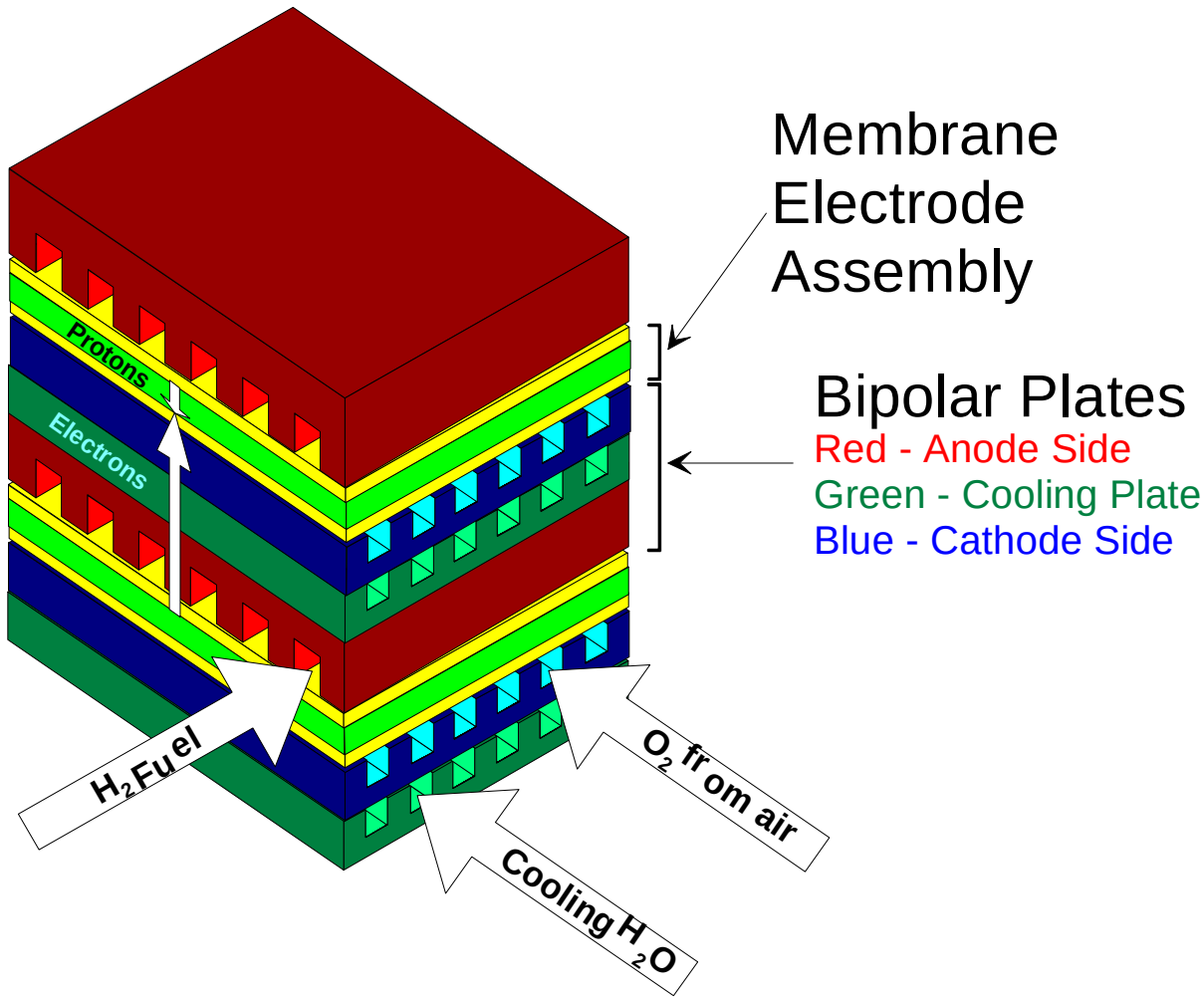
$H_2 \rightleftharpoons 2\ H^+ + 2\ e^-$

$H_2 + 1/2\ O_2 \rightleftharpoons H_2O$

PEM Fuel Cell Operation

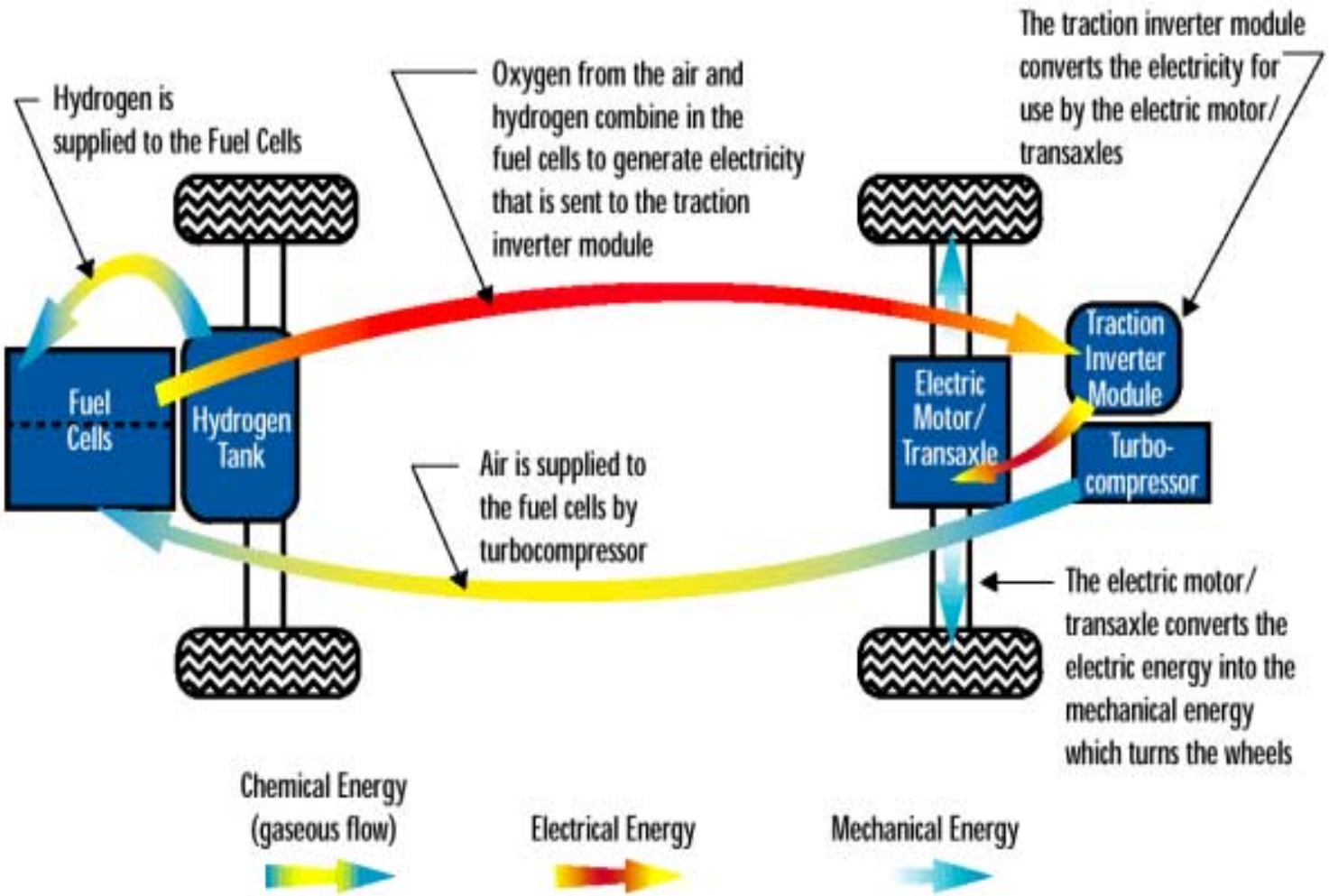


Typical PEM Fuel Cell Construction



Ian D. Sims, July 1993 - revised, JAA 02/18/99

Fuel Cell Powered Vehicle



Why Investigate Fuel Cells?

Fuel cells offer substantial benefits toward improving transportation's impact on health and environment.

Fuel Cell Vehicle Potential

What are the societal benefits?

- **Zero emission vehicle**
- **2 - 3 times the fuel economy of conventional internal combustion engines (ICE)**
- **Comparable performance as compared to ICE**
- **Sustainable Transportation**
- **Less dependence on imported oil**

*** using hydrogen fuel**

Lineage of Fuel Cell Vehicle Programs at Ford Motor Company

1998
P2000 FCEV
Gaseous Hydrogen

2000
California Demo
Ford Focus
Gaseous Hydrogen

2001
Japan Demo
Mazda Premacy
Methanol

2002
Ford Focus
FCEV Hybrid
Gaseous Hydrogen

1st Gen.

2nd Gen.

3rd Gen.

Outreach

Global Customer Development & Demonstration Program

Completed over 160 VIP Ride-n-Drive events in 2002!

Today Ford Has Five Demonstration & Marketing Vehicles -- Plus Ten Road & Test Lab Vehicles

Ford Focus, Hybrid Fuel Cell

Focus Hybrid FCV Performance Data

Driving Range (EPA 75)	**160 to 200 miles**
Fuel Efficiency (EPA75 / Highway)	**58 / 81 miles per gallon of equivalent gasoline**
Top Speed	**Over 80 mph**
Acceleration (0 - 30 / 0 - 60 mph)	**3.0 to 4.2 / 10 to 14.0 sec.**


powered by TWINAX


BALLARD

Key Features Included in 2004 Focus FCV

- Low Rolling Resistance Tires
- Regenerative Braking System
- Electro-hydraulic Power Steering System
- Electro-hydraulic Braking System (by-wire)
- Electronics Throttle (by-wire)
- Ballard Mark 902 Fuel Cell Stack
- Ballard Integrated Powertrain Drive Motor
- Sanyo Hybrid Battery System
- H2 Sensor throughout the vehicle
- Dynetek 5000 psi Tank and Regulator System
- Electric Air Conditioning
- Power Windows and Door Locks
- Colors: White, Silver and Frost Green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2004 FCV Program Overview

- Low Volume Program
- Target Market – California, considering other key markets; Canada, Germany, England, etc.
- Goal is to cluster a minimum of five vehicles in each non-target market location to support refueling logistics and learning objectives leading to our 4th Generation FCV
- Offering a three year lease program -- collaborative Learning development and test program
- Delivery in 2004
- Ford would help facilitate refueling infrastructure with our fuel provider partners – if needed.

2004 FCV Program Overview

- Continue with Marketing and Public Outreach programs jointly with lessees or agencies for example: Ford's Fuel Cells Across Canada Tour
- Ford will collect vehicle performance data to facilitate on-going collaborative development to support $4^{th}/5^{th}$ generation design as well as repair and maintenance data of 3^{rd} generation vehicles
- 2004 Program Partners will get first chance at next generation program participation
- Ford is planning several generation of FCV's before reaching commercialization target in 2010/2012 timeframe

$4^{th/}$ 5^{th} / 6^{th} Generation FCV's and Beyond

REPORT TO CONGRESS - MATRIX

Accelerated Timeline to Establish the Capability of Hydrogen Fuel Cell Vehicles (Draft)

12/17/01

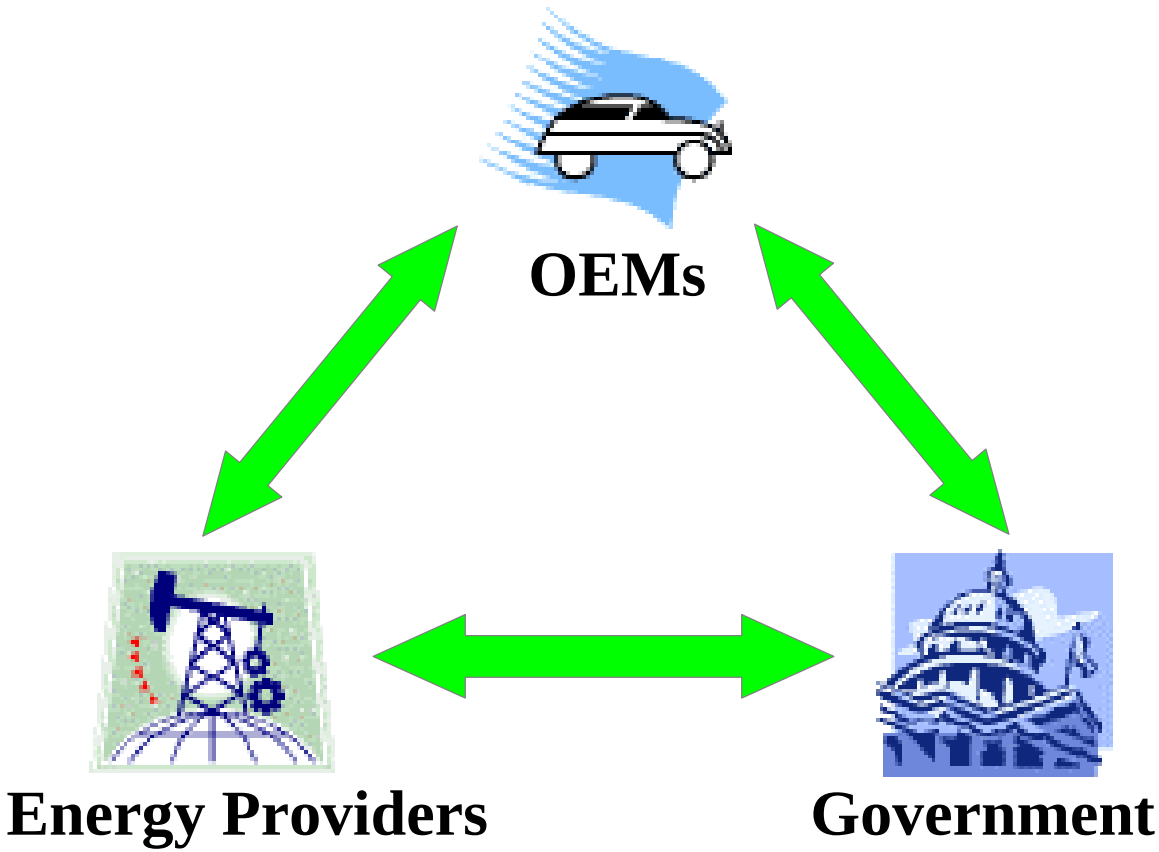
2001 — 2004 — 2008 — 2012

Demonstration Phase	Feasibility Demonstration	"Controlled" Fleet Demonstrations	Commercial Fleet Demonstrations	Commercialization Phase
Vehicles Objective	Test FC vehicle performance and feasibility	Demonstrate use of FC vehicles under real-world conditions.	Demonstrate commercial viability of FC fleet vehicles.	Investment to establish manufacturing plants and sales/service
Sites	1(CaFCP)	5-8; varying climates	2-3 states (networked sites)	
Number of Vehicles	<50	~500	~5000	
Infrastructure Objective	Demonstrate H_2 fueling station	Onsite generation from multiple feedstocks	Sufficient stations to provide consumer convenience	Investment for 25-50% of all stations H_2 capable
Hydrogen Source	Primarily trucked-in liquid H_2	Renewables and fossil fuels	Most cost effective sources	
Number of stations	3	5-10	20-30	
Government Role	Share management responsibilities Fuel Chain Analyses Education	Purchase Vehicles Cost share & operate H_2 fueling stations Data collection & dissemination Coordination of international codes & standards Education	Vehicle subsidy Cost shared infrastructure Education	Legislated incentives to consumers & industry Exercise capability for national energy security
Industry Role	Operate Vehicles and H_2 stations Primary Funding	Vehicle design, engineering & integ. Cost share fueling stations Identify service requirements Complete Codes & standards	Cost share vehicles Cost share fueling stations Gauge consumer acceptance Maintenance capability	Commercialization Phase Begins
Success Criteria [achieved through parallel technology development]				
Fuel Cell Cost (@ 500,000/year) Durability	$325/kW 1000 hrs	$125/kW 4000 hrs	$45/kW 5000 hrs	Industry Criteria
Onboard H_2 Storage Cost ($/kWh) Energy Density Specific Energy			$5/kWh 2000 Whkg 1100 Wh/L	Industry Criteria
Hydrogen Infrastructure Cost Greenhouse Gases	$40/GJ 118 g/km	$21/GJ 109 g/km	$12/GJ 98 g/km	Industry Criteria

Given the high risk nature of the accelerated timeline, careful decision criteria prior to each phase need to be jointly established by Industry and Government.

Refueling

Infrastructure Development Must Be A Cooperative Effort




EMISSIONS

Dynetek Mobile Hydrogen Fuelling Station

Who says hydrogen infrastructure is a problem?

- **Lightweight mobile trailer**
- **Self-sufficient fueling system – delivering hydrogen to remote customers**
- **Capacity of 78 kg (920 nm3) at 5000 psi**
- **Easily towed behind a pick-up truck (10,000 lbs. GVW)**

Stuart's Hydrogen Infrastructure

Scaleable Technology 1 to 100 Vehicles

Personal Fuel Appliance (PFA)

- Prototype designed for home use runs on household current 220V and tap water

- Delivered PFA to ford motor in support of ford's hydrogen projects
  - Installed on ford's tractor trailer to fuel vehicle demonstrations

Michelin Bibendum learns how easy filling up with hydrogen can be!

Challenges

Customer Wants for Commercialization "Transparent"

- Traffic compatible performance
- 200 to 300 miles range
- Convenient refueling
- Practical payload
- Good ride, handling and low NVH
- Reliable and safe operation
- Rapid start-up
- Affordable price

Commercialization Issues Today

Pros

- High fuel efficiency
- Zero tail pipe emissions
- High tech image
- Fuel flexibility (H2)
- Possible use of renewable energy

Cons

- Cost premium
- Hydrogen safety perception
- Limited refueling
- People unfamiliar technology
- Codes/Standards

The Cost Challenge

Research shows: The retail consumer will not pay a premium for Fuel Cell technology!

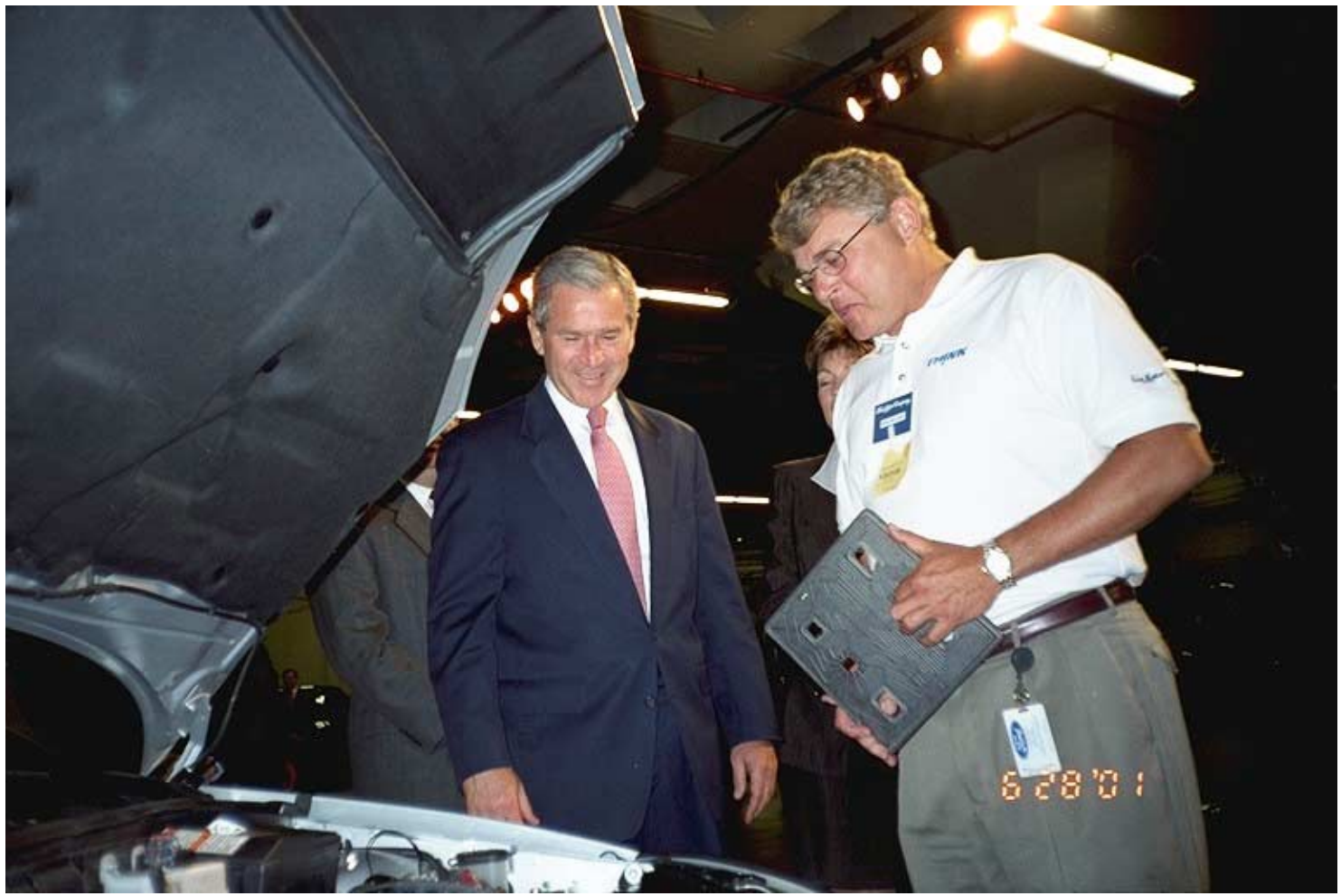
- Fuel Cell Vehicles must be cost competitive with advanced ICEs and hybrids.
- H2 must be readily available.
- Foreseeable retail sales approximately 2012 timeframe.

VIP Event Photos

P2000 with Canada's Prime Minister Chretien

WHQ - Bill Ford, Jr. with Fuel Cell Team

Educating President Bush about Ford's Fuel Cell Efforts




CONTINENTAL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